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THE BUTTERFLIES OF THE BORDERLAND BETWEEN NORTH AND SOUTH AMERICA.

Biologia Centrali-Americana. Insecta—Lepidoptera—Rhopalocera. Vols. i. and ii., 1879–1901. Pp. xlvi + 487 + 782. By Frederick Ducane Godman, F.R.S., and the late Osbert Salvin, F.R.S.

WE often hear, and are unfortunately compelled to admit, that the claims of learning are far too much neglected in our country, and that the wealth which is accumulated so much faster than in past times is but rarely under the control of men inspired as were the "pious founders and benefactors" of old. With humiliation and some perplexity we are forced to recognise that in younger lands the ancient spirit is as strong as it has ever been in history. Modern conditions have nothing to do with the indifference to learning exhibited by the average wealthy Englishman; for wealth is brought together under the newest of new conditions in the countries where it is lavishly spent in establishing and maintaining the centres of learning. And this is not only true of the most recent of Colonial and American universities. The older American universities date far back into colonial times. The life of Harvard as a university of an independent Power is even now shorter than its life in a British Colony; and yet Harvard, Yale and the other older American universities yearly receive benefactions for which Oxford and Cambridge look in vain. The needs of both Oxford and Cambridge are widely known in the country, as well as the serious lack in efficiency which both of them suffer for want of an assistance which on the other side of the Atlantic would be freely given. The difference in spirit seems to lie in a glorious "fashion" formerly dominant and powerful, but at present weak and enfeebled, in this country while it reigns supreme elsewhere. Such an interpretation is hopeful; for fashions may, and often do, revive, and even surpass, their former influence. All honour to those who in these latter days have helped on the good work in our land. Among these noble efforts on behalf of learning a prominent place will always be assigned to the munificence which has placed the investigation of the biology of Central America to the credit of British science.

The great work of which an important section forms the subject of the present article is now drawing to its close. It is, therefore, not inappropriate to say something of the biogeographical area of which the plants and animals are described in this vast monograph, or rather series of monographs, and to attempt to ascertain the reasons which induced F. D. Godman and the late Osbert Salvin to make the choice of their life-work.

However they may be divided and named, the life-bearing land-masses of the world are essentially arranged as an incomplete ring girdling the Arctic Ocean and sending three great extensions towards the south. P. L. Sclater's original classification of the zoological regions of the south, which has never been equalled by any of the later suggestions and would-be improvements, divides the northern ring into two regions, an Old-World segment and a New. It is admitted that this division is chiefly adopted for the sake of convenience and not because of any great difference between these two sections. The faunas of the three southern extensions differ widely from each other and also from those of the Holarctic belt. Interest is therefore concentrated on the point of junction between each southern extension and the northern ring, which more or less directly connects it with the two other extensions. The Ethiopian land-mass is cut off from the belt by a vast desert area. The most peculiar and interesting southern parts of the Indo-Australian mass are cut off by sea, the nearer less peculiar part by the most mighty mountain range in the world. There remains the Neotropical extension, in certain groups the most peculiar of the three, in species probably the richest, and, unlike the others, freely connected with the northern belt, the desert barrier penetrated by continuous north-and-south-running mountain ranges. Free continuity at no very distant period is in this case also proved by the reappearance of characteristic northern genera on the temperate southern Neotropical mountain ranges, such forms being wanting from the corresponding Ethiopian mountains. Furthermore, the east and west ranges of the Old-World part of the belt form barriers against which many plants were driven and exterminated by the advancing cold of the Glacial period, while in the New World the same species were able to escape southwards and return when the period came to an end.

From these considerations it is obvious that the point of junction between a south-extending land-mass, as peculiar as any of the three and far more freely continuous with the north than any other, is the most interesting and critical region in the world, and one which was bound to throw most light upon the problems of distribution. The vast importance of the thorough working out of this transition area Godman and Salvin had the genius to seize upon, as the result of their first visits, singly or together, in 1857–8, 1859–60, 1861–3—early days, when the "Origin" had only just appeared and the problems of distribution were first beginning to be attacked. So successful was the investigation, and carried on with such energy, enterprise and munificence, that this area, then obscure and little studied, has become probably better known than any other part of the world which can in any way compare with it in richness. The collections have been worked out by the most distinguished specialists, the descriptions published in the "Biologia," and with splendid generosity the whole material, labelled and complete, has been handed over to the nation, so that for all time the British Museum will be the one place in which the biology of Central America must be studied. Whatever may be true of the political sphere, the Monroe Doctrine of learning has been infringed on so magnificent a scale that any attempt at repair is hopeless, and our American friends will probably find their revenge by annexing biological territory in the Old World.

The completion of the two volumes on the Lepidoptera Rhopalocera of Central America is of especially deep interest. Here, as in the volumes on the bird fauna, we have the labour of the editors themselves, working together as more than brothers until the pathetic death of Osbert Salvin, on June 1, 1898, left the most obscure and difficult part of this great monograph still unfinished. Three more years were required before the work was completed by F. D. Godman, who speaks of the large amount of help rendered him by the skill and energy of G. C. Champion, and the value of Dr. Holland's excellent book, which would have been a still greater assistance had it become available at an earlier date.

The immense development of the Central American Hesperiidæ, that difficult group which so long delayed the completion of the work, will be appreciated when the number of species, upwards of 550, is compared with the 178 of the New-World segment of the northern belt and the 66 of the Old-World segment. The study of the Pamphilinæ was a special cause of delay, and not only here, but in the whole family, an examination of the male genitalia, requiring the preparation of immense numbers of dissections, was found to be necessary.

"In Thanaos several of the species are absolutely inseparable by external peculiarities, but markedly different in their genital structure."

Such cases are remarkable and interesting, and range with those in which the males, as in many Enploeinæ, have not hitherto been separated except by the wide difference in secondary sexual characters, viz. the conspicuous "brand" on the wings. That species should be separable only by the characters directly or indirectly associated with the reproductive system of a single sex, while these sole differentiating criteria are strongly marked and evident, suggests the possibility of sexual dimorphism, rather than specific distinction, as an interpretation. Carefully conducted breeding experiments upon a few well-chosen examples would be well worth a trial, and would speedily decide beyond the possibility of doubt as to the interpretation of an immense mass of interesting facts of which the discovery is recorded in this monumental work.

Turning to the bearing of this section of the "Biologia" upon the broad principles of geographical distribution—one of the most important aspects of the whole work—it becomes necessary first to define precisely the extent and limits of the term Central America as employed by the editors. The area will be best understood by the enumeration of the following eight component districts:—North Mexico, South Mexico, British Honduras, Guatemala, Honduras, Nicaragua, Costa Rica and Panama. An excellent account is given of the physical geography of each of these divisions, into which, for the sake of convenience, the editors have separated the whole of their area. They find that the butterfly fauna, which includes many specially modified forms, is mainly a northern prolongation of the tropical South American, and extends to Mazatlan on the Pacific side and to a little beyond Ciudad Victoria in Tamaulipas on the Atlantic, although some purely tropical genera (Eutresis, Scada, Hetæra, Ithomeis, &c.) do not extend north of Nicaragua, Costa Rica or Panama. The Atlantic slope to as far south as Costa Rica has a more abundant rainfall, a more luxuriant vegetation and an immensely richer butterfly fauna than the Pacific, the difference being especially marked in Ithomiinæ, Erycinidæ, Thecla, Papilio, &c.

While the southern forms extend northwards over the coast areas, the Holarctic fauna presses southwards along the high central plateau into Mexico and to some extent even to Guatemala, where the northern genera Argynnis, Vanessa, Limentis and Grapta are met with, and various northern species of Colias occur. On the higher levels, no strictly Alpine forms are found, the insects above timber-line being mostly stragglers from below, while the highest forests are peopled, as in corresponding Andean localities, with species of such genera as Euptychia, Archonias, Catasticta, Pereute, Enantia, &c.

From the account given above, it is clear that the boundary between the northern belt and southern extension takes, roughly, the form of an attenuated U with its concavity directed toward the north. It has already been stated that no two regional faunas in the world are more unlike than the Holarctic and Neotropical. Their extraordinary differences can only be explained by geographical separation for an immense period. At length occurred that "psychological moment" in the organic history of the world when the boundaries fused together and the two contrasted faunas were geographically free to contend and to intermix. The insight of Godman and Salvin led them to investigate the one tract of the land surface of the globe which tells us most of the results of such a struggle. The main conclusion which is impressed by the vast array of facts in the "Biologia" is that stated by Darwin in the "Origin," viz., the predominance of the organic over the inorganic environment of living beings. By the "long results of time," in other words natural selection operating for a vast period, the northern fauna as a whole has been adapted to one environment and the southern fauna to another; and when the two are at length free to invade and to intermix, very little invasion and intermixture occurs. Each fauna is "an army of all arms," as Rolleston used to express it, strong enough in its own territory to repel the attacks of the other. The metaphor is an exceedingly good one, in that it emphasises the truth that each species of the whole fauna (and flora) is not only adapted to its inorganic environment, but also to countless other species of the fauna and flora of the same region. The U-like shape of the boundary line between the two regions expresses the fact that the northern forms gain advantage in the cooler higher ground, the southern in the hotter low-lying coast areas. The occurrence of northern genera on high ground towards the south of South America can best be explained by oscillations of level and changes of climate along the north-and-south-running mountain ranges, which have given northern forms an advantage over the southern and enabled bands of immigrants to press southwards until they reached a latitude to which they were permanently better adapted than the Neotropical fauna. Further changes of level and climate would then rapidly ensure the extinction of such species in tropical latitudes, so that the southward-extending bay of the U-formed boundary in the north and the colony of mountain forms cut off in the south remain as the only evidence of invasion.

The impression made upon the north by invaders from the south is doubtless far stronger, chiefly because the northern fauna being so much poorer the successful invaders make up a higher proportion of the whole. One marked result of successful invasion is certainly seen in the 178 species of Nearctic Hesperiidæ as against the

66 Palæarctic, the effect being doubtless mainly due to that exceptionally strong power of flight to which the authors attributed the unusually wide distribution of butterflies belonging to this family. Other still more interesting intruders are the great Danaine butterflies, of which *Anosia plexippus*, the "Monarch," is the best known and the widest ranging, inasmuch as it extends far into Canada. The peculiar interest of these settlers lies in the fact that certain species of the Holarctic fauna have been profoundly modified into mimicry of them, thus proving beyond the possibility of doubt that the invasion is no new thing—like the spread of the great Danaine *plexippus* into the Philippines, the Fijis, Australia, Hong Kong, &c.

The whole of the vast mass of material in these and the great series of companion memoirs is a remarkable testimony to the insight of P. L. Sclater in drawing the outlines of his regions, of Darwin in laying down the principles of geographical distribution in the "Origin," and of Wallace in his masterly development of the subject in his great works on the geographical distribution of animals. These principles have been tested by an appeal to the facts collected with consummate skill and care from the most critical area in the world, and assuredly they have not been found wanting.

The work is printed and brought out in the same beautiful and costly style as the rest of the series. It contains 112 plates, with more than 2000 admirably executed hand-coloured figures representing 1250 species, and nearly 550 uncoloured figures of the structural parts of butterflies.

The total number of species of Rhopalocera recognised in Central America as here defined is 1805, as against 642 in the New-World and 716 in the Old-World segment of the Holarctic belt. Of these 1805, 360 (almost exactly one-fifth) are described as new. A valuable table of genera shows distinctly and at a glance the relative numbers of the species in each of the eight districts of Central America, in South America, in North America and in the West Indies. The extraordinary poverty of the fauna of the latter is well brought out by this comparison.

The classification adopted is mainly that of H. W. Bates in his paper on the insect fauna of the Amazon Valley (*Journal of Entomology*, ii. pp. 175–185, 1864). The Libytheidæ, instead of being included in the Erycinidæ, are kept as a separate family, represented in the area under consideration by a single species. One slight criticism may be suggested; the monograph begins with the most specialised subfamily the Danainæ, but within the subfamily itself the more specialised group the Ithomiina follows, instead of precedes, the less specialised Danaina.

This vast undertaking has required the cooperation of some of the best living collectors of insects. In addition to the visits of the editors, Mr. G. C. Champion, Mr. H. H. Smith and many others have remained in Central America for long periods of time collecting material for the "Biologia." Great collections, such as those of H. W. Bates and Herbert Druce, have been acquired as a whole and added to the mass of material, which was steadily accumulating for forty years. Wherever Central American specimens could be acquired or borrowed, they have been studied for the purpose of this great work; the single exception was due to the impossibility of receiving the loan of Plötz's quoted but unpublished figures. It is unnecessary to say anything further of a difficulty thus gratuitously thrown in the way of a memorable advance in zoological science, a great gift, not restricted to any single nation, but conferred upon the learning of the world.

The thorough treatment of the more obscure Central American groups and genera is such as to render the work absolutely necessary for the study of the related species in other parts of the world.

It would be inappropriate to discuss the details of this great monograph at any length on the present occasion, but all naturalists should gain a knowledge of the general results, in part briefly discussed in this article, which are lucidly set forth in the introductory chapter. And every naturalist, before he reaches the end of the record of results and conclusions, will feel how deep is the debt that he owes to the research and munificence which have led to so notable a widening of the boundaries of knowledge.

E. B. P.

PRINCIPLES OF DYNAMICS.

Sur les Principes de la Mécanique Rationelle. Par C. de Freycinet, de l'Institut. Pp. viii + 167. (Paris: Gauthier-Villars, 1902.) Price fr. 4.

M. DE FREYCINET first became known to the world as the author of a treatise on dynamics of some bulk and repute, which was published in 1858, and the essay before us shows that at the end of his long and distinguished career of active public life his interest in the subject remains unabated. Referring to his publications during the intervening period, we find two relating to dynamics. In 1887, he communicated to the Academy of Sciences (*Comptes rendus*, cv., pp. 903–910) a note containing the rather interesting suggestion that the term "dynamical capacity" should be adopted in the place of the term "density" as derived from dynamical considerations, on the analogy of calorific capacity; also some proposals about units which were not likely to meet with acceptance. He proposed a standard unit of length derived from the value of gravity at Paris, recommending it by the remark that the length of a pendulum can be measured more conveniently than that of a meridian of the earth. In 1896, he published his essays on the philosophy of the sciences, containing some chapters on mechanics.

The book before us gives the impression of not being up to date, and repetitions from the author's former works which we find in it afford some explanation of this. He does not appear to be well acquainted with the modern literature of the subject. One might expect to find some sign of the influence of Mach, but there is none. The framework of the essay is a constructive sketch of the subject, which cannot be regarded as of much value. It is chiefly interesting on account of the satisfactory tone of protest against *a priori* judgments with regard to the principles of dynamics and on account of some attempts which are made to amend the phraseology of the subject, among which "dynamical capacity" figures prominently. It is disfigured by some inaccuracies and obscurities.